

**Accessing Higher Vibrational States of  $\text{He}_2^+$  through Multi-Step Excitation**M. Holdener<sup>1</sup>, F. Merkt<sup>1\*</sup><sup>1</sup>Departement of Chemistry and Applied Biosciences, ETH Zurich

The precise measurement of highly excited vibrational states of small molecular systems such as  $\text{H}_2^+$ ,  $\text{H}_2$  and  $\text{He}_2^+$  is of significant interest as benchmark to *ab-initio* quantum-chemical calculations [1]. In the case of  $\text{He}_2^+$ , only the first few vibrational levels of the electronic ground state  $X^+ \ ^2\Sigma_u^+$  were precisely measured [2-3]. In this poster presentation, we propose a method to access the higher vibrational states of  $\text{He}_2^+$   $X^+ \ ^2\Sigma_u^+$  using a multi-step excitation scheme.

Our approach involves the production of a molecular beam of  $\text{He}_2$  in the long-lived metastable  $a \ ^3\Sigma_u^+$  state [4] through an electric discharge. We then utilize a high-intensity laser to promote the system to the electronic state  $c \ ^3\Sigma_g^+$  in an excited vibrational level with  $v$  in the range 3-5. This state predominantly decays radiatively to the  $a \ ^3\Sigma_u^+$  state with  $v' = v$  because of favorable Frank Condon factors.

A second laser is then employed to induce a transition from the vibrationally excited metastable state  $a \ ^3\Sigma_u^+(v')$  to the ion state  $X^+ \ ^2\Sigma_u^+(v^+ = v')$ . This method offers the prospect of studying the structure and dynamics of highly excited vibrational levels of  $\text{He}_2^+$  that are typically challenging to access.

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[3] Paul Jansen, Luca Semeria and Frédéric Merkt, *J. Chem. Phys.*, **2018**, 149, 154302.

[4] Cary F. Chabalowski, James O. Jensen, David R. Yarkony, Byron H. Lengsfeld, *J. Chem. Phys.*, **1989**, 90, 2504-2512.